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THE UNIVERSITY OF ALBERTA

SEX TAINT OF PORK

by

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A THESIS

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ABSTRACT

The incidence of sex taint in market swine was investigated by the olfactory analysis of subcutaneous fat by a sensory panel. Sources of material examined consisted of 48 pigs from nine litters, equally distributed between boars, barrows, and gilts, and 192 commercial swine, consisting of 80 ridgelings, 48 sows, 32 barrows and 32 gilts. In addition to sensory evaluation, selected fat samples including all the boar fats, 60 of the ridgeling fats and a smaller number of the barrow, gilt, and sow fats were chemically analysed for 5α-androst-16-ene-3-one the steroid principally responsible for sex taint.

Sex taint was detected in 56% of the boars and 62% of the ridgelings by the sensory panel. Although some of the sow fats exhibited odour defects, no evidence of sex taint was detected; nor was this taint detected in any of the gilt or barrow samples. 5α-androst-16-ene-3-one was detected in some of the boar and ridgeling fats tested. The quantity found was highly correlated with the sensory panel evaluation of the fat. No evidence of androstenone was found in any barrow, gilt or sow fat. The quantity of androstenone present in the fat tested ranged from 0.1μg/g (limit of detection) to 3.0μg/g.

Using a triangle test, tainted and control pork loin roasts were evaluated by a consumer type panel. The panel was able to distinguish the tainted from the control pork when the tainted roast was judged as moderately or strongly tainted by the sensory panel.

The control roasts were preferred in all cases where the panel was able to distinguish between them.

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INTRODUCTION

It has become generally acknowledged that the entire male pig has a more efficient rate of feed conversion than his castrated littermate. When fed a satisfactory ration, boars also reach market weight at a younger age than castrates. These traits make the raising of boars for meat economically attractive. In addition the carcass of the entire male is longer and leaner than that of castrates and has a more desirable conformation.

From the viewpoint of breeders, it would be advantageous to raise boars so that breeding stock selection could be made on the basis of an animal's own growth and feed conversion performance.

The presence of a taint in boar meat variously known as boar taint, sex taint, or sex odour, has effectively prevented the raising of boars for fresh meat, as both packing plants and government regulations discriminate against boar meat. In acknowledgement of the presence of a taint in boars the Canada Department of Agriculture instructs all inspectors that any entire male must be condemned. The waste of this potential source of high quality meat and superior breeding stock is of concern to the swine industry.

In this study, incidence and intensity of the steroid principally responsible for boar taint was studied by sensory and chemical analysis in a small number of boars raised by the Department of Animal Science, and on a large number of ridgelings (incompletely castrated males which retain one or both testicles in the abdominal cavity) which were available from commercial sources. Consumer type panel response to tainted pork was also investigated.

LITERATURE REVIEW

I. The Entire Male Pig as a Meat Animal

Use of the entire male pig has many evident advantages. Many researchers have found that boars produce leaner carcasses with better conformation characteristics than do barrows, and do so more efficiently. Charette (1961) found that boars consumed less feed than barrows while recording a similar average daily gain, due to more efficient feed to gain conversion. The boars had longer carcasses with a greater loin area and a higher percent shoulder. The boars' greater feed conversion efficiency was noted by Lidvall *et al.* (1964) who also found that boars had less backfat and a higher percent of ham and loin than barrows. Omtvedt and Jesse (1968) reported that boars required less feed per unit gain, had less backfat, a larger loin eye and a higher overall yield of lean cuts than barrows. In addition to a lower feed intake and greater feed conversion efficiency, Blair and English (1965), found that their boars recorded higher daily gains, and suggested that poorer quality diets in other studies might be preventing boars from achieving their maximum growth rate. Prescott and Lamming (1967) have shown that growth of the entire male is reduced at levels of protein sufficient for satisfactory growth in the castrate. All these studies were conducted with littermate boars and castrates raised under the same conditions with the same diet and slaughter weight.

A major disadvantage of castration is the set back in growth which increases with increasing age of the pig. If the operation

is done carelessly, without proper hygenic precaution, infection or even death may result (Charette, 1961). Because of their leaner carcass and more efficient feed to gain conversion, it should be economically advantageous to raise boars for slaughter, however discrimination against boars on the grounds that their flesh is tainted is widespread. Both government regulations and packing house practice tend to discourage the raising of boars (Self, 1957).

II. Incidence of Taint

It has been recognized for many years that pork from entire males is undesirable because of its disagreeable pungent odour which resembles the odour of urine or perspiration. Lerche (1936) stated that a taint was present in the flesh of all sexually mature male pigs and in all cryptorchids with undegenerated testicles; Heydt (1936) emphasized the seriousness of the problem in Germany and reported that at one plant, in a eight month period, twenty-two hogs were discarded due to tuberculosis and thirty-five due to sex taint.

The assumption that sex taint was confined to boars and cryptorchids was generally held until Self (1957) published a paper claiming that pigs of all sexes produced tainted flesh. To test for the presence of taint he used portions of diaphragm muscle which were heated in foil to $200^{0}F$ ($93^{0}C$) under infra-red lamps before being examined by personel of the Oscar Mayer and Co. research department. His results were as follows:

Sex	% incidence	No. of carcasses examined
barrow	17	162
gilt	18	181
boar	23	31

This research, which contradicted the previously held belief that only meat from boars and cryptorchids was tainted, stimulated further investigation of the problem of sex taint.

Williams et al. (1963) stated that sex odour was largely confined to boars, with swine of other sexes only occasionally being involved. These workers used samples of pork fat which were heated to 110°C in an erlenmeyer flask. The fat was smelled by a three member panel selected for their ability to detect sex odour. They found the incidence of taint to be:

Sex	% incidence	No. of carcasses examined
barrow	5	86
gilt	5	96
sow	1	78
boar	65	79

Further research by Elsley (1968), Pearson (1968), and Patterson (1969) suggests that sex taint is, almost without exception, confined to boars.

If there is a specific time during maturation when the taint does appear, it may be possible to slaughter boars before this taint develops. Teague et al. (1964), Echternkamp et al. (1969), and

Plimpton et al. (1971) reported boars of 70 kg live weight to be free of taint. Elsley (1968) using an experienced taste panel found taint in boars slaughtered commercially at 55 kg. He stated that at 43 kg, which is lighter than any commercial slaughter weight, boars are almost completely free of the presence of taint at a level to be detected by the consumer; while at 120 kg the meat of boars is sufficiently tainted to rule out the use of these entire males. According to Elsley, however, there is not the gradual increase in intensity or incidence of the taint between these extremes as some investigators indicate.

Wismer-Pedersen et al. (1969) tested over 1900 boars from four months to six years of age for sex taint. He found strong taint in boars of all ages; and the proportion of the boars which were tainted did not differ at different ages. Sixty to seventy percent of the boars tested exhibited taint of varying strength. He concluded that there was no age effect on the intensity of sex odour. Nor did he find a relationship between sex odour intensity and the boars' ability to mate.

III. Influence of Castration and Implantation of Diethylstilbesterol on Sex Taint Reduction in Boars

Since the sex taint is largely confined to entire males, it has long been assumed to be related to sexual maturity. The first attempt to eliminate the taint from the live animal was by Lerche (1936). He slaughtered mature stags at intervals from 8 to 75 days

after castration. Using a sensory test he found that the taint had lessened considerably after 33 days, and completely negative odour tests were obtained after 68 days. The compound thought to be responsible for sex taint has been synthesized _in vitro_ by Gower (1968) from boar testis homogenate.

Teague _et al._ (1964), Echternkamp _et al._ (1969), and Plimpton _et al._ (1971) have used diethylstilbesterol (DES) implantation of boars at various weights in an attempt to repress the sex odour and flavour of the meat, and to increase daily gain, while maintaining the long, lean carcass characteristic of the entire male. Teague _et al._ reported that 96 mg of DES implanted at 70 kg live weight was effective in suppressing boar odour and flavour and significantly improved the rate of gain. All implanted boars were rated as more acceptable than the control non-implanted boars. Few, however, rated as highly as barrows. Similarly, Echternkamp _et al._ found implanted boars to have less taint odour and flavour than control boars as well as a higher daily gain in weight. The odour and flavour were not compared with barrows in this investigation. Plimpton _et al._ reported that the reduction in sex odour and flavour which occurred in DES implanted boars persisted for ten weeks, after which time the implanted boars were not significantly more acceptable than the control boars.

IV. Chemical Nature of Sex Taint

Little was known until quite recently regarding the nature of the compound or compounds responsible for the sex taint other than the fact that heating was required to volatilize the odour and make sensory detection possible.

In 1959 Dutt _et al._ reported that the taint was lipophilic and originated in the prepuce. Craig _et al._ (1962) found that the taint was present in the unsaponifiable fraction of the fat and required heating to 100°or 110°C for optimum volatilization. Apparently it was not possible to isolate the taint material from fatty tissue by distillation of the whole tissue or of the extracted liquid fat.

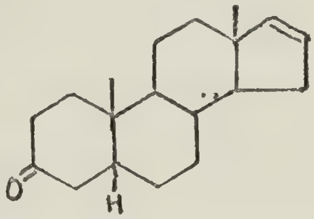
Williams and Pearson (1965) made a more complete fractionation of the unsaponifiable matter, identifying many components including carbonyls, cholesterol, and saturated hydrocarbons. None of these, however, proved to be responsible for the taint.

Patterson (1966, 1968a) utilizing Dutt's findings (Dutt _et al._ 1959) that sex taint originated in the prepuce studied the components of boar preputial fluid and identified a wide variety of odouriferous compounds. He concluded that although volatiles contributed to the odour of the live boar, none was a major component of the sex taint of pork. In a later paper (1968b) Patterson identified the major or sole component of sex taint as 5α-androst-16-ene-3-one (androstenone). He isolated the component by high-vacuum distillation of the melted fat followed by gas chromatography. The identity of the compound was

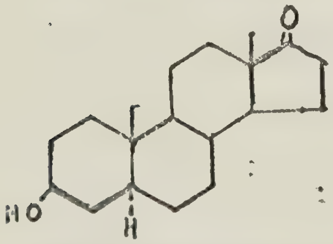
confirmed by mass spectroscopic analysis of material collected from the exit of the gas chromatograph while the odourous peak was being eluted. Patterson (1969) found up to a tenfold variation in the concentration of androstenone between pigs of the same age, weight, and genetic background; maximum concentration in the fat of market weight pigs was 2 ppm. He attributed the variable concentration and erratic incidence of androstenone to the fact that it is not in the direct metabolic pathway involved in production of androgenic hormones.

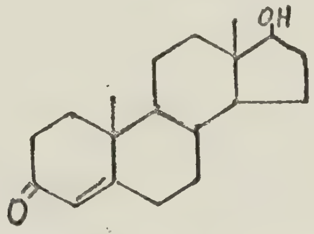
V. Origin of 5α-androst-16-ene-3-one

Androstenone



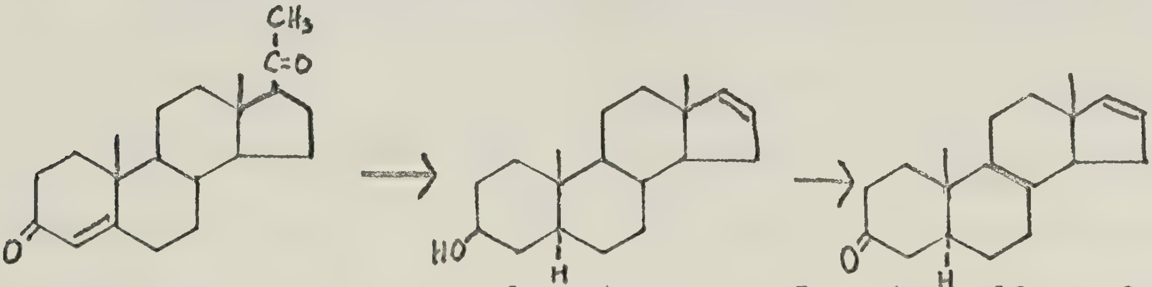
is structurally closely related to the male sex hormones, especially androsterone: and testosterone:





Androstenone has been biosynthesized in vitro (Katkov and Gower, 1968) from pregnenolone and from progesterone using boar testis homogenate. The exact mechanism has not been elucidated, however a separate pathway from testosterone synthesis is in operation, since neither testosterone nor its precursors--such as testosterone acetate and dehydroepiandrosterone--are effective precursors for 5α-androst-16-ene-3-one. A suggested pathway for the in vivo synthesis of

androstenone involves conversion of progesterone to 3α-hydroxy, 5α-androst-16-ene (androstenol) which is then oxidized to the ketone.



progesterone 3β-hydroxy, 5α-androst-16-ene 5α-androst-16-ene-3-one

The exact mechanism of the conversions have not yet been fully elucidated. The androstenol was found in boar testis by Prelog and Ruzicka (1945) and has also been reported to be present in urine, plasma, and the submaxillary salivary glands of boars (Katkov and Gower 1968; Patterson 1968b, 1968c). It has been found in human urine of males, and of females with virilizing adrenal cortical carcinoma (Gower and Stern, 1969).

Patterson postulated that the site of oxidation of androstenol to the androstenone is the salivary gland, where both steroids may be found. The mechanism of the reaction at this site has not been thoroughly investigated. He suggests that when the saliva is swallowed the lipophilic androstenone would, as a result of normal digestion processes, be incorporated into the fatty body tissues; while the more hydrophilic androstenol would preferentially be eliminated in the urine as a free steroid or as a glucuronide ester.

VI. Methods for Detection of Taint

Testing for the presence of the taint in all research and for purposes of eliminating sex-tainted pork has been done subjectively up to the present time. The tissue to be tested is heated, either by dry heat or in boiling water, and any odour which may be volatilized is detected by the sense of smell. Both panels carefully selected for their ability to detect taint, and larger less specific panels have been used. A minimum of three members is usually considered necessary to allow for individual variations in sensitivity (Patterson, 1968b). Some panels were specifically instructed to identify and evaluate the pungent perspiration-like or urine-like odour of the androstenone, while others simply rated the samples as pleasant or unpleasant without considering the nature of the odours detected.

Subjective tests can be useful but due both to individual variations in sensitivity and to differing methods of presenting and interpreting odour test data, it is desirable to have confirmatory objective tests. The objective test used on the fat at present is Patterson's method (1968b). This test involves a six-hour, high vacuum distillation and, while satisfactory for research purposes, it is too time consuming and tedious for routine analysis. Urine and plasma steroids are isolated by solvent extraction followed by column and thin-layer chromatography. A simple and rapid chemical method is needed if routine analysis of the taint compound is to be carried out. Such methods, however, are difficult to devise for a

single specific steroid molecule.

VII. Sensory Detection of Sex Taint

Griffiths and Patterson (1970) studied human olfactory response to androstenone. They found that 7.6% of the women and 44.3% of the men tested (total of 300 subjects) were unable to detect the odour of 800 ng of the pure androstenone on a watch glass. Of those who could detect the odour, women found it significantly more unpleasant than did men. Since it is during cooking that the meat will be judged as acceptable or not, Griffiths and Patterson suggested that future testing programmes be orientated to sample the opinion of consumers who are most likely to be involved in cooking and preparation of pork. The temperature at which androstenone is volatilized, perhaps by steam distillation, is 100°C; below this temperature it is not easily detected. This temperature is achieved during cooking but by the time the pork is served it may have cooled to a point where the taint is not noticable. Volatilization of androstenone during cooking may cause the cook to discriminate against pork in future buying even though those eating the meat may not have found it unpleasant.

VIII. Acceptability of Boar Meat

Martin _et al._ (1968) evaluated pork from 36 boars, 36 barrows, 36 gilts and 36 ridgelings. A panel of six judges rated the meat for cooking odour, flavour, tenderness and overall preference. They

found that while boar meat had the poorest cooking aroma, it was rated as equal to the meat of barrows and gilts for flavour, and rated highest for tenderness; giving it the best score for overall preference. Martin concluded that boars could be marketed commercially and recommended that a routine screening procedure be performed on all swine carcasses to detect and remove carcasses of any sex which displayed objectionable taints. He further suggested (Martin, 1969; Jarmoluk, Martin, and Fredeen, 1970) that a hot soldering iron could be used to volatilize a section of fat and permit odour detection while the carcasses were hanging in cold storage.

Pearson (1968) found no significant difference in panel preference between meat loaf products made with tainted and control pork. His sixty member untrained panel found the meat loaf products made with tainted pork to be as acceptable as those made with control pork; this applied both to cold and to warm samples. Pearson felt that boar meat could be used quite successfully if the proper precautions were taken. Pork which is slightly tainted could be used in meat-loaf products as well as in institutional service where those eating the meat are not in close contact with the cooking odours. Strongly tainted pork, however, might have to be discarded.

EXPERIMENTAL METHODS

I. Source of Pork Examined in this Investigation

In this study subcutaneous fat samples for sensory evaluation and gas liquid chromatography (GLC) analysis were obtained from two sources:

1. Pigs from the Animal Science Department, University of Alberta.

This source was made available by Dr. John Bowland at the conclusion of a feeding experiment and included 48 pigs equally divided between boars, barrows, and gilts. Because of Canada Department of Agriculture regulations prohibiting the slaughter of boars at registered meat packing plants, one-half of the pigs: 16 boars, 4 barrows, and 4 gilts were slaughtered at an unregistered meat packing plant from which it was possible to obtain large enough fat samples to permit vacuum distillation for GLC analysis, and sensory testing. From the remainder of the pigs, slaughtered in a registered meat packing plant, only small samples of fat were available--sufficient for sensory testing.

2. Commercial pigs from meat packing plants.

A total of 198 pigs were obtained from this source and included samples of ridgeling (cryptorchid), barrow, sow, and gilt fats. The ridgelings, which according to Canada Department of Agriculture marketing statistics account for 1% of all the male pigs slaughtered, provided the only other available source of boar taint in

this study. The marketing regulations permit the slaughter of these pigs, as they are not classified as boars, but provide for the condemnation of all such carcasses on which a pronounced taint is detected. Fat samples from these commercial carcasses (weight range 130 - 180 lbs. dressed weight) randomly selected by Veterinary Inspectors were evaluated by sensory and GLC analyses.

Pork loin roasts from ridgelings having a range of boar taint intensities were selected at a meat packing plant and compared with untainted roasts. The loins were wrapped in foil and stored at -20°C until prepared for roasting. Before roasting, the meat was defrosted at 5°C for 24 hours, and at that time, a sample of fat was removed for odour evaluation and GLC analysis.

II. Odour Evaluation

Evaluation of the fat for sex odour was carried out by an expert panel that, although no rigorous screening was carried out, consisted of members who had demonstrated ability to detect boar taint in frying fat.

The fat samples, thin slices weighing approximately 3 g, were heated in individual aluminum foil dishes to about 110°C. Odours emanating from the heated fat samples were concentrated and prevented from dispersing by a large aluminum foil hood which was placed around the hot plate and sample. The hood could easily be cleared of odour by removing it and fanning the area to provide fresh air.

The panel was asked to evaluate the intensity of boar taint as follows: no taint, slight taint, moderate taint, and strong taint. For the purpose of statistical analysis these descriptive responses were given numerical values. The use of numerical scores is convenient in permitting calculations of mean values but the arbitrary nature of the scale must be borne in mind. The values given the description evaluations of intensity were:

no taint --------	0
slight taint --------	1
moderate taint --------	2
strong taint --------	3

III. Preparation of Standard Androstenone

5α-androst-16-ene-3-one was prepared by chromic acid oxidation (Bowden _et al._, 1946) of the alcohol 3αhydroxy,5α-androst-16-ene; both the α and the β alcohols were successfully oxidized. The chemical reaction involved is:

$$3RHOH + 2CrO_3 + 3H_2SO_4 \longrightarrow 3RO + 6H_2O + Cr_2(SO_4)_3$$

Twice the theoretically calculated amount of chromic acid was prepared (solution B) and added very slowly to a micro reaction vessel containing the acetone solution of the androstenol (solution A). Oxidation was almost instantaneous as evidenced by the immediate production of the green chromic ion colour. Very small amounts of the oxidant were added at intervals until a faint orange tinge indicated an excess of dichromate ion. The solution was then diluted

with 1 ml of water and extracted with 4 x 1 ml aliquots of diethyl ether. The combined organic extracts were evaporated to dryness and the residue taken up in 500 μl of hexane and stored at 4°C.

The solution volumes used in oxidizing 6 mg of androstenol were as follows: Solution A, androstenol, 6 mg (0.022 millimoles) in 250 μl of acetone; Solution B, chromic acid, 2.5 mg CrO_3 (0.025 millimoles), 10 μl H_2O, 1.6 μl concentrated H_2SO_4, and 250 μl acetone.

IV. Chromatographic Analysis of Fat for Sex Taint Component

1. Preparation of the fat

After comminution in a chilled food grinder or by fine chopping with a knife, the kidney or back fat was melted in an oven operated at 90°C and connective tissue and other fibrous solids were removed by centrifugation at a speed of approximately 2350 rpm for 3 minutes in an Atlas Juice Master lined with 3mm filter paper. The melted fat was then dried over anhydrous sodium sulphate, filtered through a Whatman No. 1 filter paper, under vacuum, and stored at -20°C under an atmosphere of nitrogen until analysed.

2. Preparation of the samples for Gas liquid chromatography

The procedure for preparation of the sample for GLC separation was similar to that described by Patterson (1969).

i. Distillation

Fifty ml of the melted fat were poured into the bottom half of the pot-still apparatus (fig.1), the top half was then carefully lowered onto the o-ring seal and the whole clamped together.

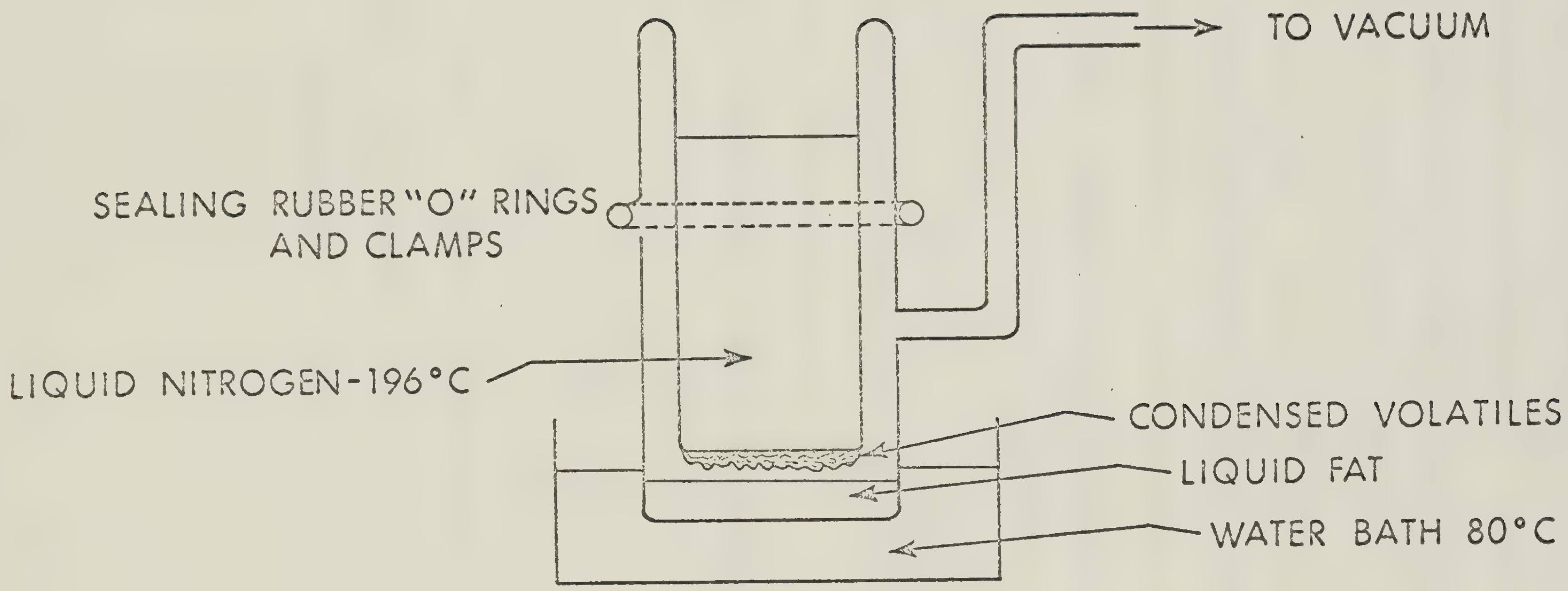


Figure 1. Pot Still (according to Patterson, 1969). Material volatilized by the 10^{-3} mm Hg. vacuum and 80°C temperature condensed on the outside wall of the liquid nitrogen trap from whence it was dissolved sequentially with ethanol and diethyl ether at the end of the distillation.

Liquid nitrogen was added gradually to the cold trap during the deaerating and heating up period. The fat was deaerated by controlled reduction of the pressure--with constant stirring by a magnetic stirrer to minimize the spattering of the fat onto the surface of the cold trap--by a high-vacuum pump unit consisting of an oil diffusion pump backed up by a rotary vacuum pump. Heat was provided by circulating water from a bath which was heated to and maintained at $80^0C \pm 1^0$ with a thermostatically controlled immersion heater.

At the end of the distillation (6 hr) the apparatus was disassembled and the trapped material dissolved from the cold surface with a few ml of ethanol followed by diethyl ether until no detectable odour remained on the glass surface.

The combined solvent washings (approximately 20 ml) containing the distillate were then concentrated to 2 ml in a rotary evaporator, saponified with 10 ml of 0.1 N aqueous NaOH for 15 minutes at room temperature, diluted with 90 ml of distilled water and twice extracted with 30 ml aliquots of diethyl ether:hexane (15:85, v/v). The organic solvent extracts were combined, dried over anhydrous sodium sulphate, filtered and concentrated to 250 µl in a stream of nitrogen at room temperature.

ii. Thin layer chromatography

Fifty µl of the concentrated solution, prepared above, was dispensed onto glass plates coated with silica gel G spread 200 microns thick and activated for 1 hr at 100°C. Development was carried out in methanol:benzene (3:97, v/v) for 120 mm and when dry the band between 60 and 100 mm--reported by Patterson to contain the taint component--was scraped off into a fritted glass buchner funnel and estracted with 20 ml diethyl ether. This solution was concentrated to 250 µl by passing a slow stream of nitrogen into the tube to effect evaporation of the excess solvent. The 250 µl was transferred to a small test tube and stored at 4°C until chromatographed. To confirm that the material in the sample was the same compound as the standard androstenone, two further chromatographic systems were used as described by Gower (1964) and Lisboa and Palmer (1967). The first involved developing a standard silica plate 3 times in benzene:ether (9:1,v/v) and in the second the material was spotted on silica gel plates impregnated with 25% $AgNO_3$ and developed in benzene:ethyl acetate (1:1,v/v). The chromatogram was visualized by spraying with 50% sulfuric acid and heating (charring) until the spots appeared.

iii. Gas liquid chromatography

Gas liquid chromatographic analysis was carried out on an F.&M. (F.&M. Scientific Corp. Avondale, Pa.) model 810, dual column gas chromatograph equipped with hydrogen flame ionization detectors.

In order to use the glass columns recommended for steroid analysis the column-adaptor set up supplied by the manufacturer,

which requires the use of a glass-to-glass joint sealed by O-rings and swagelok fittings, was replaced by custom-made columns. At the high sensitivities required, the small amount of leakage that results from glass-to-glass joints--especially as the O-rings age--can cause an excessively noisy baseline which decreases the effective sensitivity. To avoid this loss in sensitivity custom-made columns which connect directly from the injection port to the detector were designed (Fig. 2a). These columns were fitted to the A column which was then used for recorded chromatograms. The standard column and adaptor was used on column B (Fig. 2b) to connect to the auxillary detector outlet for the trapping of samples.

The 3 ft, ¼in OD glass columns were acid washed with 10% HCL and silanized using Siliclad according to the manufacturers directions before packing with Chromosorb G 80/100 mesh, acid washed, dimethyldichlorosilane treated, coated with 5% silicone gum rubber (SE 30) and 5% phenyldiethanolamine succinate (PDEAS) in a ratio of 5:2 by length.

Operational parameters were as follows:

oven temperature --------- 180°C
carrier gas, nitrogen --------- 60 ml/min
hydrogen flow --------- 60 ml/min
air flow --------- 300 ml/min
injection port temperature --------- 238°C
detector temperature --------- 240°C

Quantitation was achieved by comparing areas, determined

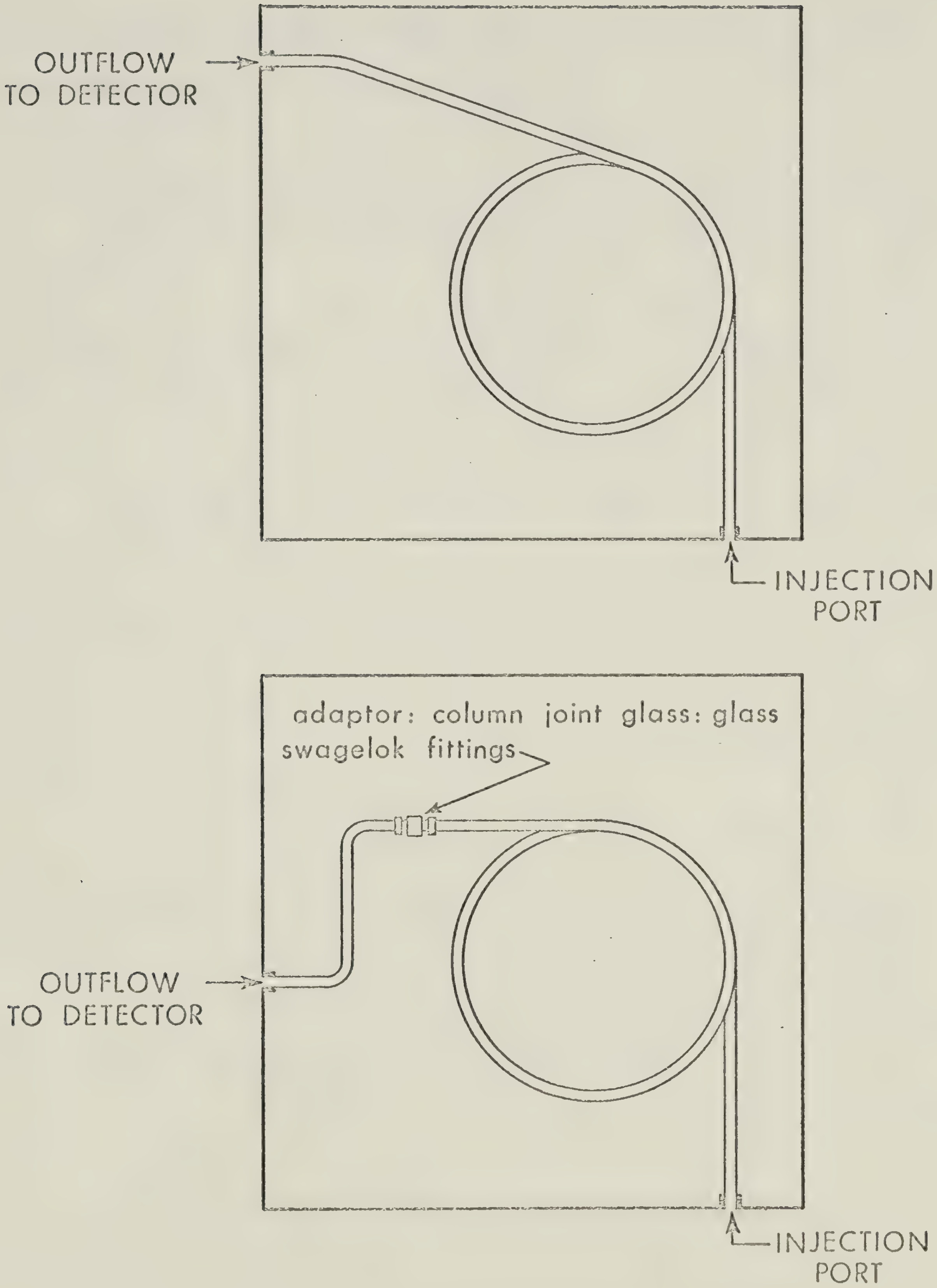


Figure 2. Gas chromatograph thermostatic oven showing location and design of columns. A. custom-made column, connecting injection port with flame ionization detector; B. Manufacturers column and adaptor showing joint leading to thermal conductivity detector to permit collection of column effluent.

by triangulation (height x width at half-height), with a standard curve prepared using 5α-androst-16-ene-3-one.

V. Consumer Type Panel Detection of Sex Taint in Roasted Pork Loins

Ridgeling pork loin roasts with varying amounts of sex odour as judged by the expert panel were compared with normal market pork, by consumer type panels averaging 18 members, to determine whether there was a detectable flavour difference between the two types of meat. The members of the expert panel were included in this panel.

After thawing at 5°C for 24 hr a ridgeling and a market loin were roasted, while wrapped in aluminum foil, in identical pans in a 185°C oven to an internal temperature of 83°C. The roasted loins were then cut in slices and the individual slices foil wrapped, coded, and returned to a warm oven. As the tasters arrived they were served samples taken directly from the oven.

A triangle test (Larmond, 1970) was used to determine whether the panelists could detect a difference in flavour between the ridgeling and the market pork. Two samples of market pork loin and one of ridgeling pork loin were served to each panelist, who was instructed to indicate the odd or different sample.

RESULTS

I. Odour Evaluation

Analysis of variance of fifty panel scores was computed in order to determine if there was a significant difference between the judges. An F value of 1.9 which is not significant at the 10% level, indicated that there were no differences in the panel members' scores for any given sample; thus the averageing of scores was acceptable and the scores given for any sample are the average of the opinions of at least three judges.

1. Commercial pork fat samples

The thirty-two barrows and thirty-two gilts obtained from commercial meat packing plants were found to be free from any evidence of boar taint. The fifty sow fat samples tested were also found to be free from boar taint although several possessed an unpleasant and distinctly different odour.

Results for the eighty ridgeling fat samples tested are given in Table 1. The panel found that 62% of the ridgeling samples were tainted: 5% were strongly tainted, 21% were moderately tainted, and 36% were slightly tainted; while 38% of the samples were judged to be free of any taint.

2. Pork fat samples provided by the Department of Animal Science

A total of forty-eight littermate pigs were examined for boar taint (see Appendix for breed and growth details). As was the

Table 1. Sensory evaluation of the presence of sex taint in ridgeling fat samples obtained from local packing plants.

Sample number	Taint description	Rating	Sample number	Taint description	Rating
A3	slight	1	A36	no taint	0
A8	no taint	0	A37	no taint	0
A13	no taint	0	A38	slight	1
A14	no taint	0	A39	slight	1
A15	no taint	0	A40	moderate	2
A16	no taint	0	A41	no taint	0
A17	no taint	0	A43	no taint	0
A18	slight	1	A44	moderate	2
A19	no taint	0	A45	slight	1
A20	no tiant	0	A46	moderate	2
A25	slight	1	A47	slight	1
A26	slight	1	A48	slight	1
A27	slight	1	A49	slight	1
A28	slight	1	A50	moderate	2
A30	slight	1	A51	moderate	2
A31	moderate	2	A52	slight	1
A32	no taint	0	A53	slight	1
A33	no taint	0	B1	slight	1
A34	no taint	0	B2	slight	1
A35	no taint	0	B3	no taint	0

Table 1 continued.

Sample number	Taint description	Rating	Sample number	Taint description	Rating
B4	strong	3	B29	no taint	0
B5	no taint	0	B30	moderate	2
B6	moderate	2	B31	moderate	2
B7	no taint	0	B44	no taint	0
B8	no taint	0	G1	no taint	0
B9	slight	1	G4	moderate	2
B10	no taint	0	G10	strong	3
B11	moderate	2	G11	slight	1
B12	strong	3	G12	slight	1
B13	strong	3	G13	slight	1
B14	no taint	0	G14	slight	1
B15	no taint	0	G18	slight	1
B16	slight	1	G19	no taint	0
B17	slight	1	G21	moderate	2
B18	slight	1	G22	slight	1
B20	no taint	0	G27	moderate	2
B21	slight	1	G28	moderate	2
B22	moderate	2	G29	moderate	2
B23	no taint	0	G31	moderate	2
B28	no taint	0	G32	slight	1

case with the commercial samples, all barrows and gilts were free from taint. Odour panel results for the boars are given in Table 2. The panel found 56% of the boars to be tainted: 19% were strongly tainted, 25% were moderately tainted, and 12% were slightly tainted; 44% of the boars were considered to be free from taint.

3. Fat samples from pork utilized in consumer type panel tests

Fat samples taken from the pork loin roasts used for the consumer-type panel tests were examined by the sensory panel for presence of boar taint. The results are shown in Table 3. None of the control market pork was considered tainted while five of the six ridgeling fat samples were tainted to some extent.

II. Preparation of Androstenone Standard

The identity of the standard prepared by chromic acid oxidation of androstenol was ascertained by several analytical tests. Using thin-layer chromatography, the R_f value of the oxidation product was found to be 0.60, which was within the range of 0.5 to 0.8 indicated by Patterson (1968b). A second TLC procedure using a different solvent system, benzene:diethyl ether (9:1, v/v), gave a standard as well as a sample spot with an $R_f$value of 0.25 (Fig. 3). When $AgNO_3$ impregnated silica gel was used and developed in benzene:ethyl acetate (1:1, v/v) a standard and a sample spot at R_f 0.37 were seen (Fig 4). GCL analysis of the androstenol and androstenone produced peaks with retention times of 18 and 22 minutes, respectively, as

Table 2. Sensory evaluation of the presence of sex taint in boar fat samples obtained from the Department of Animal Science, University of Alberta.

Sample number	Taint description	Rating
DD51	strong	3
DD52	moderate	2
DD53	slight	1
DD61	no taint	0
DD62	no taint	0
DD71	slight	1
DD72	no taint	0
DD73	moderate	2
DD74	no taint	0
DD80	no taint	0
DD81	strong	3
DD84	no taint	0
DD90	moderate	2
DD91	no taint	0
DD92	strong	3
DD93	moderate	2

Table 3. Sensory evaluation of the presence of sex taint in fat samples from the ridgeling pork loin roasts used for the consumer type taste panel.

Sample number	Taint description	Rating
T1	moderate	2
T2	moderate	2
T3	no taint	0
T4	strong	3
T5	moderate	2
T6	slight	1

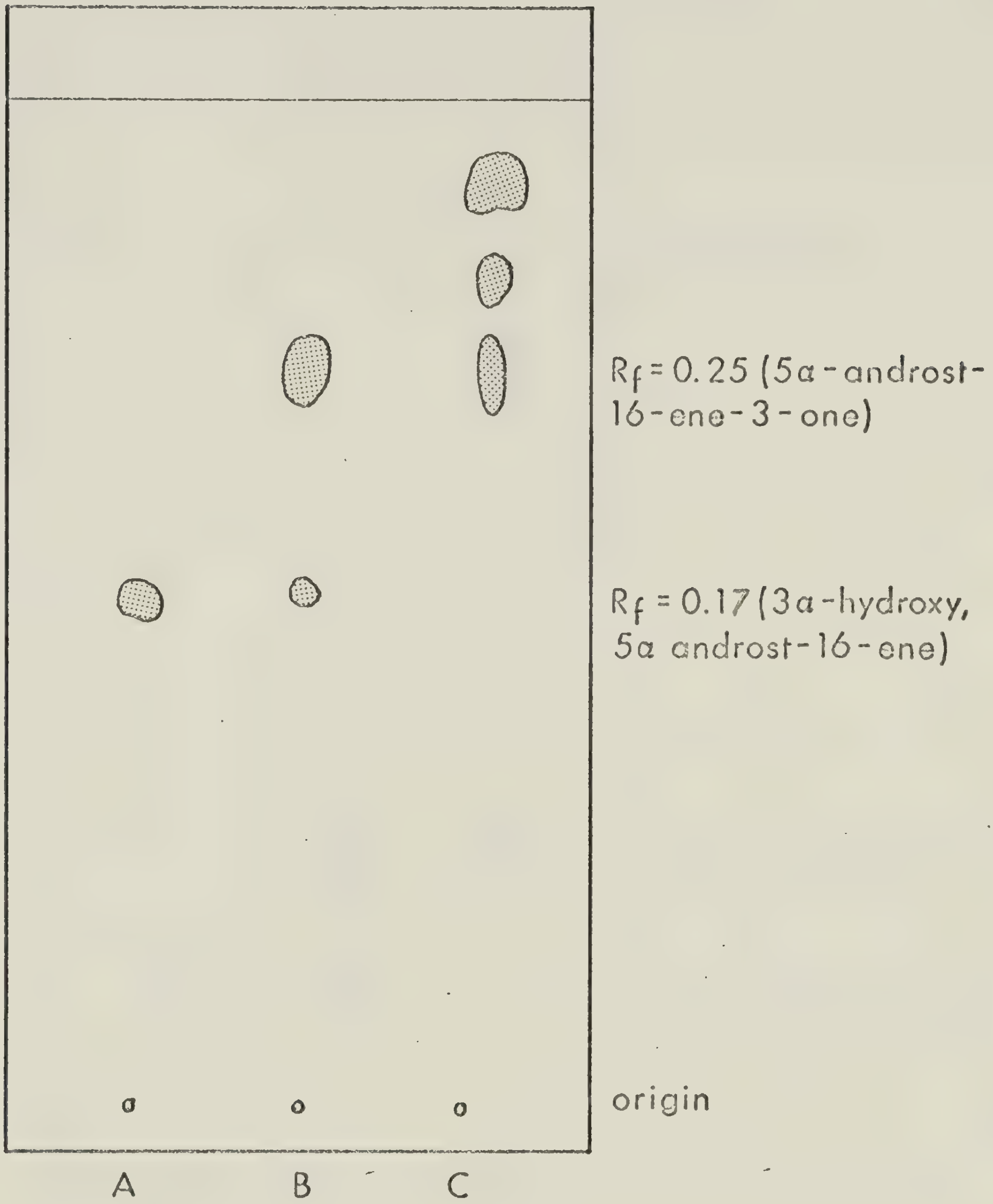

$R_f = 0.25$ (5α-androst-16-ene-3-one)
$R_f = 0.17$ (3α-hydroxy, 5α androst-16-ene)
origin
A
B
C

Figure 3. Thin-layer chromatogram of standards and sample developed 3x in benzene;ether (9:1, v/v). Solvent front 45 cm. Spots made visible by charring with sulfuric acid.
A. 3α-hydroxy,5α-androst-16-ene; B. 5α-androst-16-ene-3-one; C. a sample.

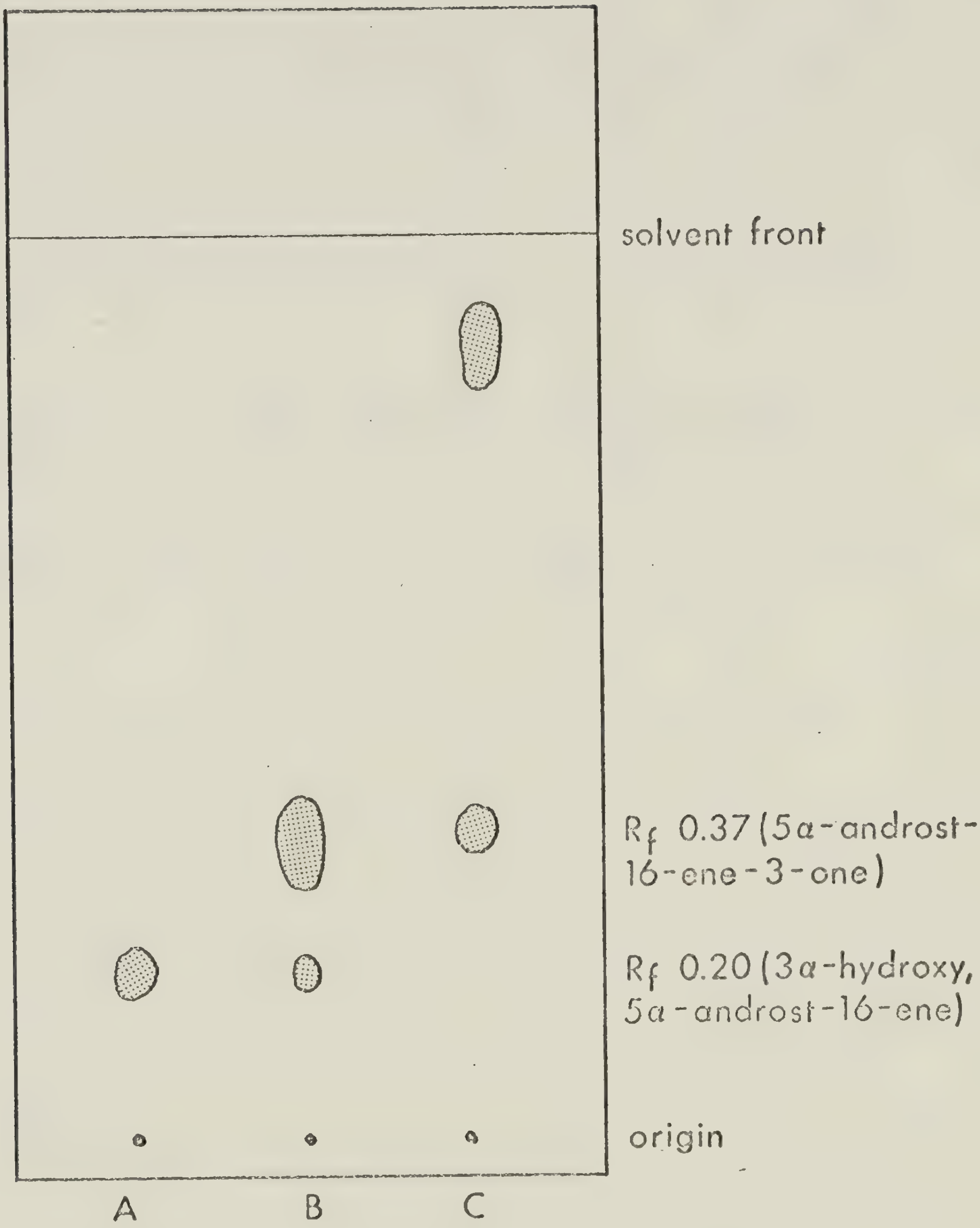

solvent front
Rf 0.37 (5α-androst-16-ene-3-one)
Rf 0.20 (3α-hydroxy, 5α-androst-16-ene)
origin
A
B
C

Figure 4. Thin-layer chromatogram of standards and sample on $AgNO_3$ impregnated silica gel, developed in benzene:ethyl acetate (1:1, v/v). Solvent front 15 cm. Spots made visible by charring with sulfuric acid. A. 3α-hydroxy,5α-androst-16-ene; B. 5α-androst-16-ene-3-one; C. a sample.

shown in Figures 5a and 5b. The GLC peak showed that the reaction had proceeded to approximately 90% completion. When mass spectroscopic analysis was applied to the prepared androstenone it was established that the compound had the characteristic spectral pattern of 5α-androst-16-ene-3-one (Patterson 1968c), that is, the molecular ion at 272 and prominent ion peak at 257 (loss of methyl group) and 239 (loss of water) (Fig. 6). The odour was the same as that detected in the fat of those boars and ridgelings judged as tainted by the sensory panel. A standard curve of androstenone vs peak area was prepared for quantitation of androstenone in fat distillate (Fig. 7).

III. Chromatographic Analysis of Fat for Sex Taint Component

All of the boar samples and 60 of the 80 ridgeling samples were analysed by GLC, a smaller number of sow, gilt and barrow samples were selected for chemical analysis (GLC) since sensory evaluation indicated that the ketone that causes the taint was not present in these latter groups.

When the concentrated distillate of some of the fat samples was subjected to TLC analysis, a chromatogram, such as seen in Figure 8 was produced. A spot having an R_f value of 0.6--the same as the androstenone standard--could be seen within the area which was to be scraped and extracted. The inclusion of impurities which appeared as spots outside the scraped area was avoided by this TLC proceedure. Gas liquid chromatographic analysis of the material

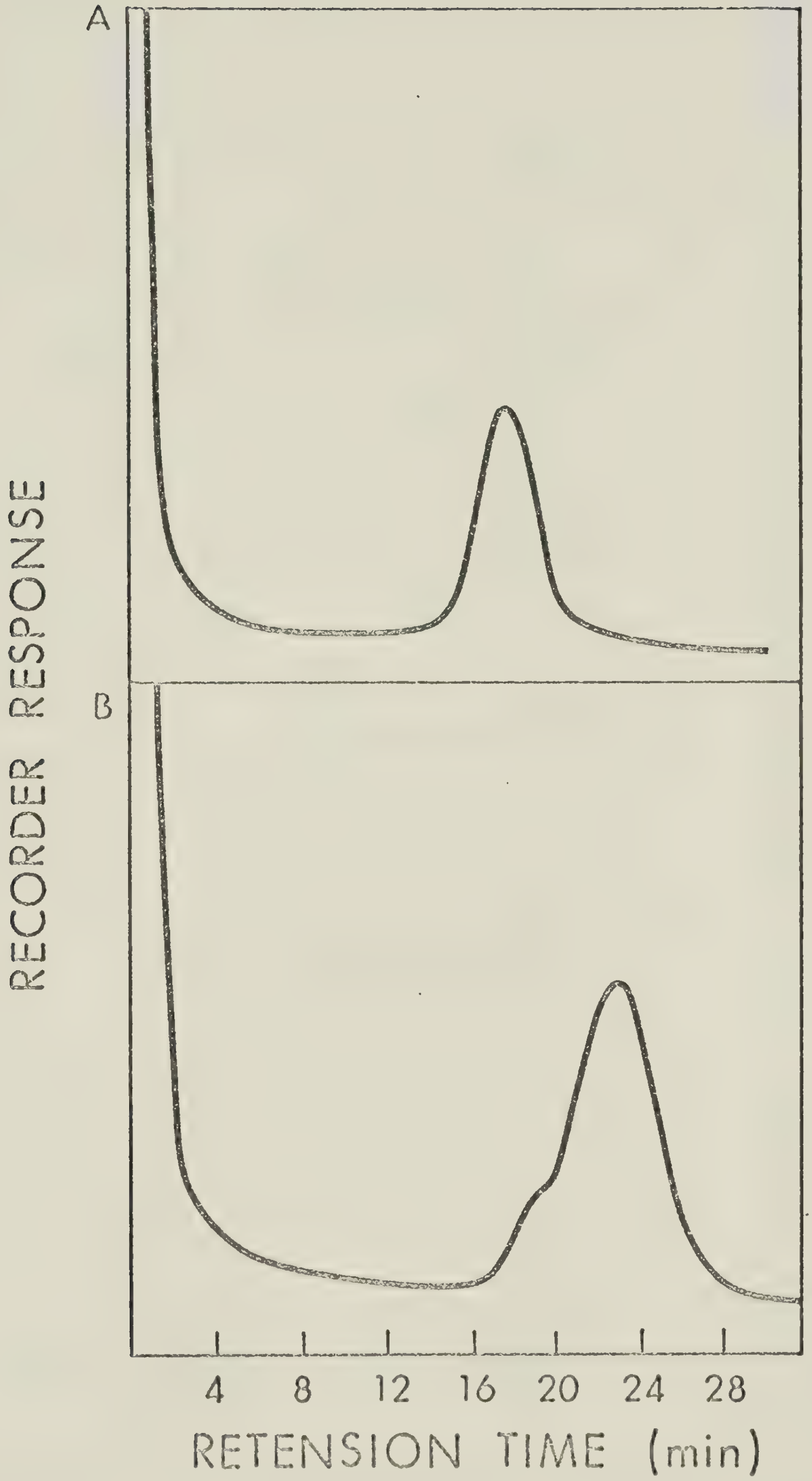


Figure 5. Gas liquid chromatograms of standards. Column: SE30:PDEAS 5:2 by length (3 ft column). A. 3α-hydroxy,5α-androst-16-ene; B. 5α-androst-16-ene-3-one.

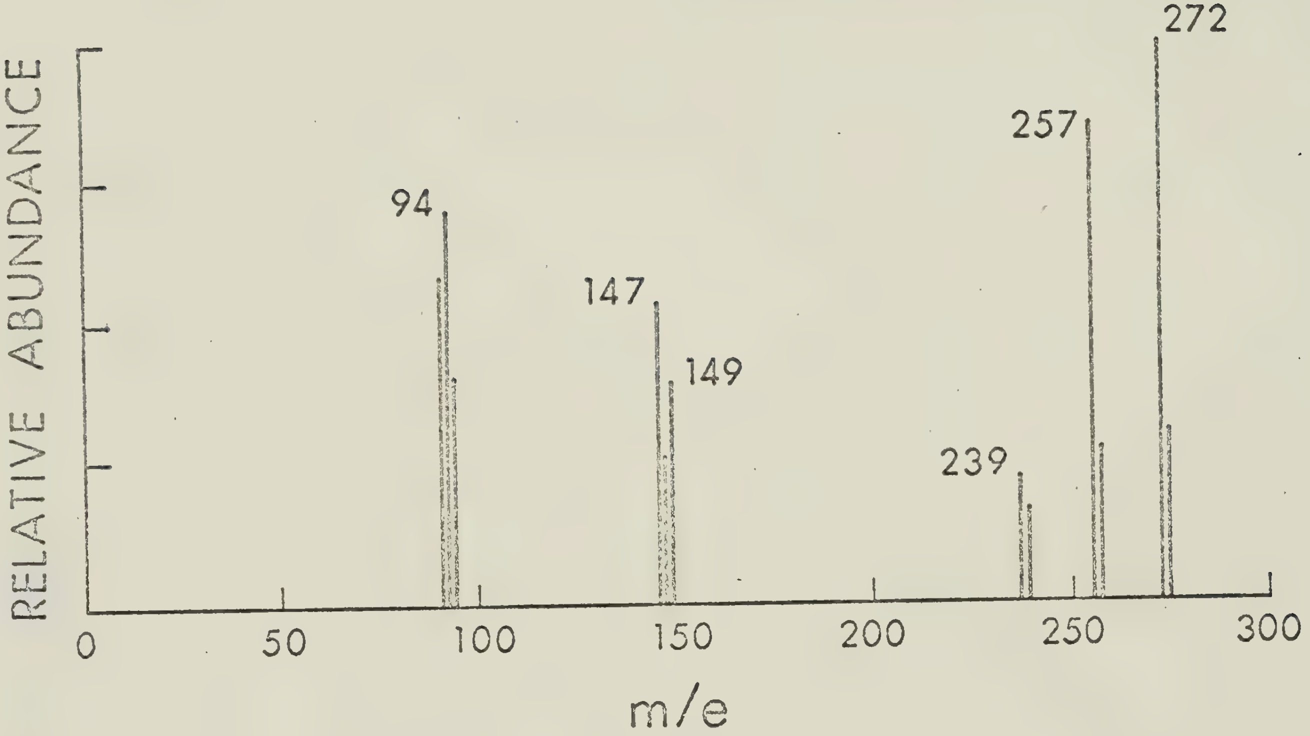


Figure 6. Mass spectrum of 5α-androst-16-ene-3-one prepared by chromic acid oxidation of androstenol. Metropolitan-Vickers MS2, 70 ev, direct probe - source temperature 200°C.

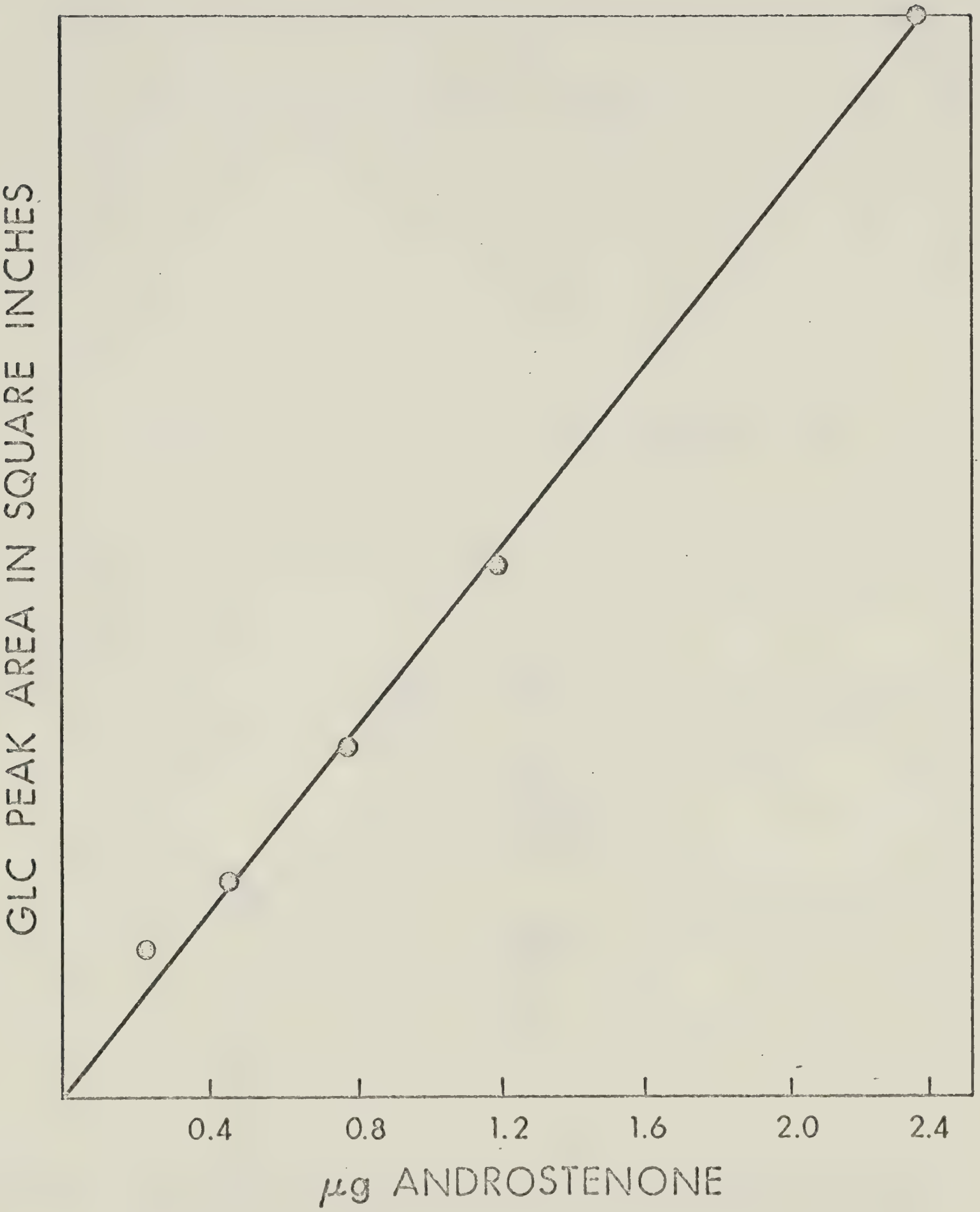


Figure 7. Standard curve of peak area (height x width at half height) in square inches vs μg 5α-androst-16-ene-3-one.

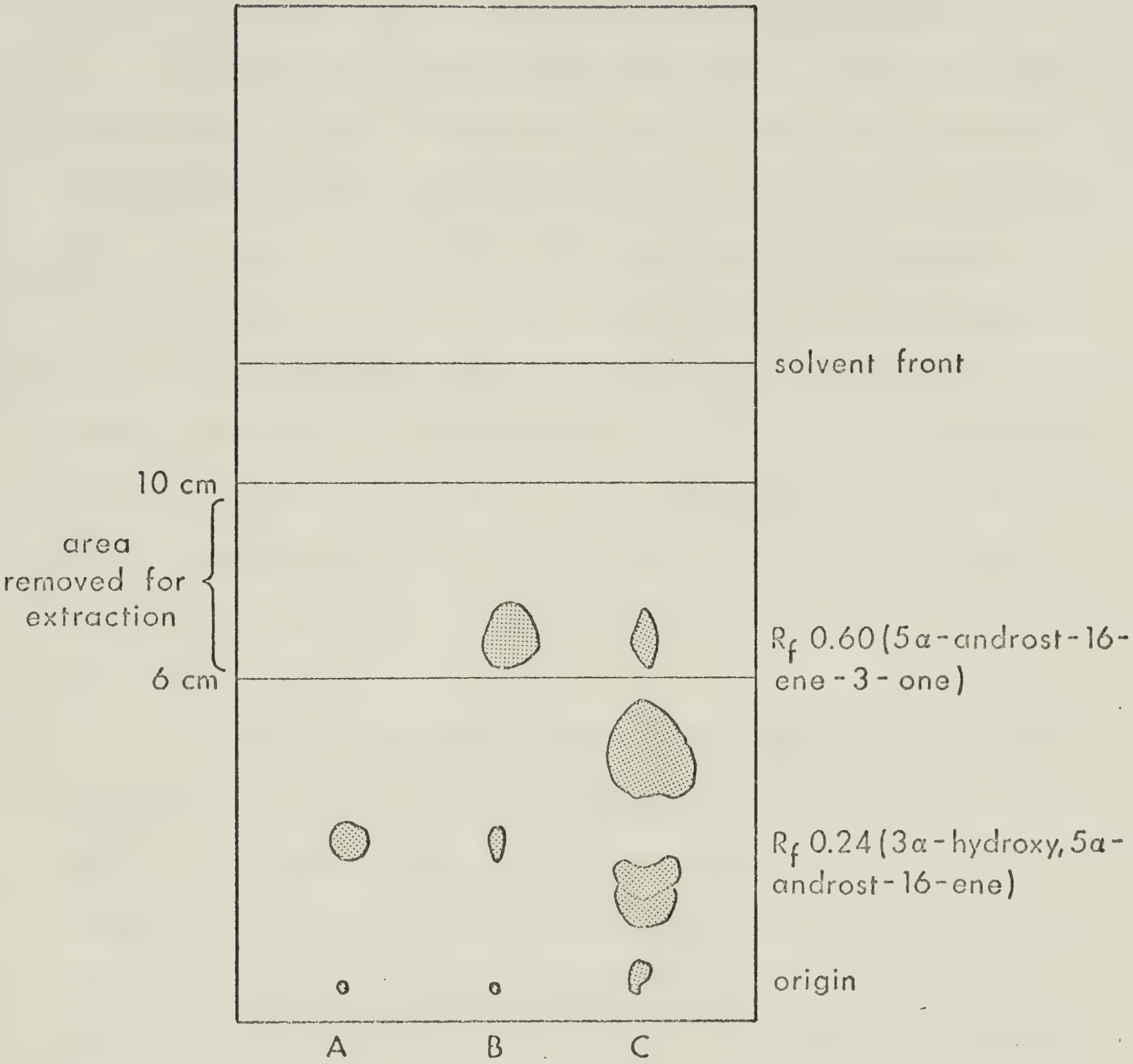

solvent front
10 cm
area removed for extraction
6 cm
R_f 0.60 (5α-androst-16-ene-3-one)
R_f 0.24 (3α-hydroxy, 5α-androst-16-ene)
origin
A
B
C

Figure 8. Thin-layer chromatogram of standards and sample developed in methanol:benzene (3:97, v/v). Spots made visible by charring with sulfuric acid. A. 3α-hydroxy,5α-androst-16-ene; B. 5α-androst-16-ene-3-one showing traces of residual androstenol; C. concentrated fat distillate. Sample size: A and B, 10μg; C 25μl of concentrated distillate.

before and after thin-layer chromatography confirmed that the TLC proceedure removed many of these short retention time impurities.

A typical gas chromatogram from a boar fat which contained androstenone is shown in Figure 9a; ridgeling fats which contained androstenone produced similar chromatograms. A barrow fat chromatogram, an example of the barrow, gilt, and sow fat chromatograms is shown in Figure 9b. In contrast with the boar fat chromatogram, the barrow fat chromatogram contains no peak in the region of the androstenone standard peak. The detection of as little as 0.1 ppm androstenone in the fat was achieved in this investigation. The sensitivity of the instrument was such that the presence of the androstenone could not be established with any degree of confidence at levels of less than 0.1 ppm.

To test the recovery of androstenone from the distillation proceedure, lard containing $1\mu g/g$ and $2\mu g/g$ was analysed in the same manner as the boar fat samples. On four trials performed the percentage recovery was 49,50,55, and 65; the average recovery was 55% and the results given in Tables 4 (boars) and 5 (ridgelings) have been adjusted to take this into account. The quantity of androstenone found in the fat ranged from $0.1\mu g/g$ to $3\mu g/g$--this latter result in one very odouriferous boar.

The correlation between androstenone and odour evaluations was found to be 0.62 for boars and 0.33 for ridgelings; these results are significant at the 1% level. This indicates that the strength of the boar taint is directly related to the quantity of androstenone present.

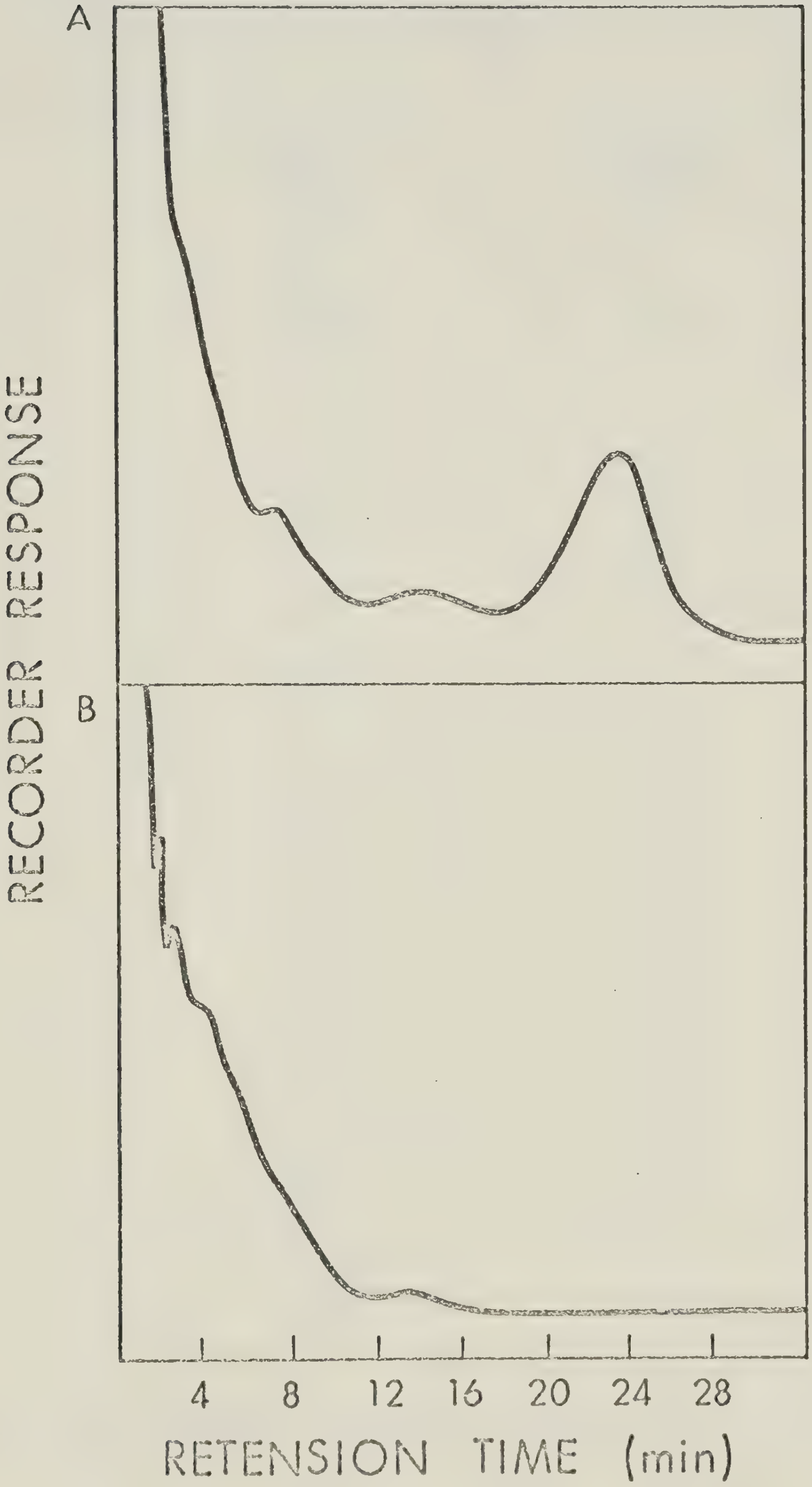


Figure 9. Gas liquid chromatogram of pig fat distillate.
Column: SE30:PDEAS 5:2 by length (3 ft. column).
A. boar fat; B. barrow fat.

Table 4. Quantity of 5α-androst-16-ene-3-one found to be present in boar fat samples obtained from the Department of Animal Science, University of Alberta.

Sample number	Androstenone (μg/g)
DD51	3.1
DD52	1.2
DD53	0
DD61	0
DD62	0
DD71	0
DD72	0
DD73	1.2
DD74	0
DD80	0
DD81	0.1
DD84	0
DD90	0.6
DD91	0
DD92	0.6
DD93	0.5

A value of "0" indicates less than 0.1μg/g.

Table 5. Quantity of 5α-androst-16-ene-3-one found to be present in ridgeling fat samples obtained from local packing plants.

Sample number	Androstenone (μg/g)	Sample number	Androstenone (μg/g)
A3	0.2	A30	0
A8	0	A31	0.1
A13	0	A32	0
A14	0	A33	0
A15	0	A34	0
A16	0	A35	0
A17	0	A36	0
A18	0	A37	0
A19	0	A38	0
A2o	0	A39	0
A25	0	A40	0.3
A26	0	A41	0
A27	0	A43	0
A28	0	A44	0

A value of "0" indicates less than 0.1μg/g.

Table 5 continued.

Sample number	Androstenone (μg/g)	Sample number	Androstenone (μg/g)
A45	0.2	B22	0.3
A46	0	B30	0.2
A47	0	B31	0.1
A48	0.3	G4	0.1
A49	0	G10	1.0
A50	0.3	G11	0
A51	0	G12	0
A52	0	G18	0
A53	0.2	G21	0.5
B4	0	G22	0
B6	1.5	G27	0
B9	0	G28	0.1
B11	0.7	G29	1.0
B12	1.0	G31	0.3

Fat samples were removed from the pork loins used for the taste panel tests before and after cooking and both samples were tested for the presence of androstenone. No significant difference was found between the before and after cooking samples and the results in Table 6 are averages of the two determinations. None of the normal market pork fat which was used as a control contained detectable androstenone. Odour panel results were correlated with the quantity of androstenone detected for the ridgeling samples; the correlation coefficient was 0.78 which is significant at the 5% level. This confirms that greater boar taint intensity is associated with higher androstenone levels.

Samples of fat from several sows which the panel described as having a strong and unpleasant odour not resembling boar taint were subjected to chromatographic analysis. Since the odour of these samples was distinctly different from boar taint and none was found to have an "androstenone peak", it would appear that any taint which may occur in sow fat is of a different nature than the boar taint ketone.

IV. Consumer Type Panel Detection of Sex Taint in Roasted Pork Loins

For the consumer type taste tests, panelists were served with two normal market pork samples and one ridgeling pork sample, and asked to identify the odd sample and state whether the odd sample or the pair was preferred. Data from the six triangle-test taste panels were analysed according to Larmond (1970). The results are shown in Table 7. In four of the six cases the panel correctly identified the

Table 6. Quantity of 5α-androst-16-ene-3-one found to be present in fat samples from the ridgeling pork loin roasts used for the consumer type taste panel.

	Androstenone (μg/g)		
Sample number	Uncooked fat	Cooked fat	Average
T1	0	0	0
T2	0.17	0.23	0.2
T3	0	0	0
T4	0.46	0.54	0.5
T5	0.13	0.07	0.1
T6	0	0	0

A value of "0" indicates less that 0.1μg/g.

Table 7. Analysis of results from consumer type taste panel

Sample number	No. of panelists	No. correctly identifying odd sample	Level of significance	No. preferring duplicates	Level Significance	Odour panel rating
T1	20	17	0.1%	13	5.0%	2
T2	20	13	1.0%	11	5.0%	2
T3	18	8	n.s.	-	-	0
T4	17	11	1.0%	11	0.1%	3
T5	17	10	5.0%	10	1.0%	2
T6	17	8	n.s.	-	-	1

odd sample and in each case preferred the pair or normal market pork sample to the odd or ridgeling sample.

In this particular experiment which involved 25 males and 9 females no difference was found in their ability to discriminate between normal and tainted pork.

DISCUSSION

I. Odour Evaluation

The decision as to what type of panel to employ must rest on whether one wishes to compile consumer acceptance data or whether one is using the panel as an analytical tool. If the panel is to be used for laboratory research purposes not only must the members be sensitive to the specific odour sought, but they must also be able to detect that odour amongst a composite of odours. A consumer acceptance panel on the other hand need merely state a preference for one sample over another or indicate that the sample being tested has an unpleasant odour, regardless of the nature of the odour.

It must be borne in mind that results from the two types of panels cannot validly be directly compared, because they were established with different objectives. The studies to which reference was made were classified as follows: (a) analytical tool--this type of panel was used by Patterson (1968b), Williams *et al.* (1963) and Elsley (1968); (b) consumer opinion panels--this type of panel was used by Self (1957) and Martin (1968). The USDA (1968) results cannot be classified due to lack of details of the methods used for the sensory tests. In the present study the sensory panel was designed as a specialized odour panel for analytical purposes and could be classified as an analytical tool panel.

The odour panel was composed of three judges who were sensitive to boar taint; in addition three other persons sensitive to this odour

occasionally served on the panel. The use of several judges to detect taint is recommended by Patterson (1968b) both because of the variation in the capacity of carious individuals to detect boar taint, and to compensate for day to day fluctuations in olfactory sensitivity. Williams et al. (1963) also used a three member panel, selecting his panelists for their ability to detect sex odour. Elsley (1968) employed a carefully selected and highly sensitive panel of four members to detect sex odour and noted that because his panelists had been selected for their ability to detect taint, they would be more sensitive that the average consumer. His panel would thus be serving as an analytical tool rather than as a consumer acceptance panel.

In the present study also, it is probable that the panel detected as taint, samples which most people would consider normal and acceptable. It is also true that there is the occasional person to whom even a very slight taint is not only distinct but extremely obnoxious and consequently before decisions involving odour frequency and intensity results can be made it must be decided whether it is the highly sensitive or the average consumer who is being considered. If it is the highly sensitive, then boars and ridgelings should be used with great caution, on the other hand average consumers may not detect slightly odouriferous samples, and to them even a moderate taint may easily be hidden by the spices of meat loaf products (Pearson, 1969).

In this research none of the 96 barrows and gilts tested was found to be tainted. This is in agreement with Patterson (1969) who found no evidence of taint in 24 barrows and gilts tested.

Conversely, Williams _et al._ (1963) found a 5% incidence of sex odour in 182 barrows and gilts tested, while Self (1957) reported a 17% incidence of taint in several hundred barrows and gilts examined. Unlike most other researchers who tested fat for odour, Self tested diaphragm muscle. It seems probable that in some of the studies reported other unpleasant odours, that could occur in fat or tissue, have been mistaken for the urine or perspiration-like odour of boar taint.

No odour resembling boar taint was found in sow fat, although other unpleasant odours were occasionally detected. This is in general agreement with the results reported by Williams _et al._ (1963) who found only one instance of an odour resembling boar taint in 78 sows, but contradicts the findings of the USDA (1968) and Self (1957) that 20% and 17%, respectively, of female swine were tainted. Self's results were based on the examination of 181 gilts and sows, whereas the USDA data were obtained on 103 sows. As indicated above extraneous odours may have confused those panelists not especially chosen for their ability to distinguish the odour of boar taint.

The results obtained for the incidence of taint in boar fat samples were similar to those reported by other researchers who used the sensory panel as an analytical tool. Elsley (1968) found 56% of 180 boars to be tainted with 5.5% being strongly tainted and Williams _et al._ (1963) reported a 64% taint incidence in 79 boar carcasses with 28% strongly tainted. Reports of higher incidence of taint, USDA (1968) 75%; Lerche (1936)100%, and lower incidence, Self (1957) 26%; Charette (1961) 0%, appear in the literature. Lack of

uniformity in the methods of sensory testing, particularly the type of taste panel and its selection, is undoubtedly an important contributing factor in the variability of the incidence of boar taint reported by these investigators.

The boars in this study were relatively young, as they reached a market weight of approximately 90 kg in an average of 157 days on a ration containing 13 to 18% of protein. In spite of this rapid growth, 56% were found to be tainted and of these 19% exhibited a strong taint. Since the taint causing substance androstenone is associated with sex hormones, it seems logical that the quantity present will probably increase with an increase in hormonal output as sexual maturity is attained. Palmer _et al._ (1971) found the first appearance of spermatozoa in a boar at 140 days, by 160 days spermatozoa were numerous and the boar could be considered to be sexually mature. The boars in this study are quite young for Canadian market weight but in all likelyhood they are sexually mature. The number of boars tested in this study is admittedly small but the results obtained confirm that a substantial proportion of market weight boars (approximately 60%) have tainted fat.

Slaughter of cryptorchids or ridgeling pigs is permitted and as a consequence there is little monetary loss to the producer when such animals are marketed. For this reason there has not been as extensive research into sex taint in ridgelings as there has been in boars. The incidence of taint in the 80 ridgeling samples tested was 62%. This figure supports the USDA (1968) report that over 50%

ridgelings tested were tainted as well as earlier reports (Heydt, 1936; Lerche, 1936) describing as general the incidence of taint in ridgelings.

II. Preparation of Standard Androstenone

Because the authentic steroid was not commercially available, it was necessary to prepare the androstenone from 3α-hydroxy, 5α-androst-16-ene by chromic acid oxidation (Jones' oxidation). Bowden et al. (1946) state that with readily oxidizable alcohols satisfactory results are obtained with the theoretical quantity of oxidizing agent, but when oxidation is slow, the use of an excess of chromic acid is desirable. Consequently, to ensure fairly rapid completion of the reaction, chromic acid equal to two times the theoretically required quantity was used.

Immediate GLC analysis of the oxidation products revealed that a small amount of residual alcohol remained after the oxidation reaction and consequently a yield of approximately 90% androstenone was obtained. Comparisons of these chromatograms made directly after the reaction was completed and of chromatograms made some time later showed that at least some of the residual 3α-hydroxy, 5α-androst-16-ene left in the reaction mixture after oxidation epimerized to the 3β-hydroxy,5α-androst-16-ene on standing. This was subsequently demonstrated by the addition of the 3αalcohol followed by GLC analysis which then revealed three peaks, indicating the presence of both 3α-hydroxy,5α-androst-16-ene and 3β-hydroxy, 5α-androst-16-ene as well as the 5α-androst-16-ene-3-one. This

conversion of the residual 3αalcohol to the 3βalcohol did not affect the effectiveness of the prepared standard.

Confirmation of the chemical identity of the oxidation product was obtained by mass spectroscopic analysis which revealed the characteristic peaks of 5α-androst-16-ene-3-one as reported by Patterson (1969). Examination of the mass spectrum of the prepared androstenone revealed that the relative abundance of some molecular ions was different from the abundance shown in a published spectrum (Beery, 1971) but comparison with a mass spectrum of 3α-hydroxy, 5α-androst-16-ene indicated that this was the source of the excess ions. Specifically at 241, 259 and 274 m/e the ion peaks were more prominent than would be expected for 5α-androst-16-ene-3-one; these correspond to the major ion peaks of the 3αandrostenol.

Thin-layer chromatographic analyses were also carried out to confirm that the compound found in the tainted fat was androstenone. The R_f values of the spots produced in the chromatographic procedure by the standard and by tainted fat samples were within the range reported by Patterson (1969). Development in a second solvent system showed both the standard androstenone and the pork fat distillate to have spots with identical R_f values. In the third system, using silver nitrate impregnated silica gel, the standard and sample produced spots with an R_f value of 0.37 which corresponded with the R_f value of 0.34 reported by Gower (1964) for 5α-androst-16-ene-3-one. These three chromatographic procedures, combined with the sensory evidence indicate that the component in boar fat which is principally

responsible for its taint is 5α-androst-16-ene-3-one.

III. Chromatographic Analysis of Fat for Sex Taint Component

Patterson's finding (1968b) that androstenone is the major cause of boar taint and his perfection of a satisfactory procedure for concentrating this compound and quantitatively measuring it by GLC has provided an objective method for determining the presence of boar taint in pork fat. However, this method requires sophisticated laboratory equipment and at least two working days to complete an analysis. Consequently its application is restricted to research in which it is desirable to determine the presence of androstenone quantitatively. No more convenient chemical proceedure is currently available for this purpose and consequently for rapid estimation of the taint in fat, sensory analysis must continue to be used. At present the only swine examined for taint in Canadian packing plants are ridgelings on which an unusual odour is detected as the carcass comes from the scalding tank. When this occurs samples are removed from such carcasses and taken to a laboratory to be tested for taint by olfactory examination of the frying fat. Jarmoluk _et al._ (1970) have developed a more rapid method for packing line testing in which a hot soldering iron is used on the carcass to heat the fat and volatilize the taint component. By this method it would be possible to test all ridgeling carcasses and thereby provide an existing testing system for boar carcasses in the event that present regulations are altered to permit the slaughter of boars. Jarmoluk found good

correlation between the soldering iron test and a panel which examined the frying fat. In the present study there was a good correlation between a sensory panel examination of frying fat and quantitative estimation of androstenone. It appears, therefore, that sensory methods will continue to be used for rapid tests to determine the extent of taint in fat.

The recovery of added androstenone achieved in this study averaged 55%, lower that Patterson's reported recovery of 90%. The methodology, therefore, was scrutinized to establish where losses could have occurred. The vacuum of the system was checked by an accurate mercury M^c^Leod gauge and found to be at least 10^{-3} mm of mercury, the same as reported by Patterson. Differences in extracting the steroid from the silica gel might be one of the most likely points for losses to occur. With the instrument used androstenone can be detected in concentrated fat distillate containing the equivalent of 0.05μg/g, when these figures were corrected for methodical losses a value of 0.1μg/g of androstenone in the fat was obtained. If the recovery had been more nearly optimal it should have been possible to detect androstenone concentrations as low as 0.05μg/g and thus some of the samples how described as slightly tainted but on which no androstenone was detected may have contained detectable androstenone. The range of androstenone found, 0.1 to 3.0μg/g, is in agreement with the range of 0.2 to 2.0μg/g reported by Patterson for market weight boars.

The median amount of androstenone detected in samples which the panel rated as having a slight taint was 0.15μg/g, for those rated

moderate the median value was 0.65μg/g and for those rated as strongly tainted it was 1.45μg/g. Analysis showed a statistically significant correlation (P=.01) between the odour evaluation and androstenone values (0.33 for ridgelings and 0.62 for boars). No relationship was found between carcass weight and taint intensity for ridgelings or between slaughter weight or age and taint intensity for the boars (see appendix). In both cases, however, only animals in the usual 90 kg slaughter weight range were tested.

GLC analyses of several unpleasantly odouriferous sow fats did not reveal the presence of androstenone, nor are there reports in the literature on the finding of androstenone in sow fat since it was reported by Patterson (1968b) as causal agent of boar taint. It would appear that the enzymes responsible for the conversion of progesterone and pregnenolone to androstenone are not active in the sow since these steroids, which have been shown to be precursors of androstenone in testis tissue by Katkov and Gower (1968), are present in the pregnant sow (Frye, 1967). In those reports which claim that sow and gilt fats contain boar taint it is possible that either the panel is confusing other odours with taint or an unusual sex phenotype is involved. True and pseudo-hermaphrodites, both of which show evidence of male hormone activity, are known to occur in swine (Bishop, 1969). He also observed that abnormal adrenal function with excessive elaboration of the steroid hormones, including androgens, is a well known condition in some species and may also occur in the pig. Detection of androstenone in the fat of female swine could indicate the presence of these conditions, but such reports

have not yet been published. Until such evidence appears it may be assumed that the urine or perspiration-like androstenone odours, such as were found in sows in this study are being described as sex taint.

IV. Consumer Type Panel Detection of Sex Taint in Roasted Pork Loins

A triangle test was chosen to best provide a means of ascertaining whether or not panelists could detect a difference between the ridgeling and the control pork. The invariable use of the ridgeling meat as the odd sample as opposed to the pair was adopted due to the belief that using two normal samples and one abnormal sample leads to far superior taste discrimination than the reverse situation (Amerine _et al._, 1965).

From an examination of Table 7 it can be seen that the consumer panel was able to distinguish between ridgeling roast and the control when the ridgeling fat was considered moderately or strongly tainted by the sensory panel. Whenever the panel correctly identified the odd sample, the duplicate or control pork sample was preferred. The consumer panel was unable to distinguish ridgeling pork from normal pork when the former was scored by the sensory panel as not tainted or slightly tainted. The good correlation between the consumer type panel results and the sensory panel evaluation of the pork may have been assisted by the cooking procedure which prevented excessive losses of taint by serving the meat wrapped and warm.

It should be borne in mind that the panel involved in

evaluating was an inexperienced panel. Although many of the members had participated in other flavour panels and were familar with general sensory testing procedure, no effort was made to train them to specifically identify the boar taint odour as the reason for their discrimination between samples, nor were they necessarily aquainted with the androstenone odour. It could be assumed, therefore, that unlike the sensory panel, the panelists for the consumer type panel were probably no more sensitive than the average consumer. If this assumption is accepted, then it is clear that the consumer will discriminate against fresh pork rated as moderately or strongly tainted, since not only was such pork differentiated from normal pork used as a control, but in each case the control was preferred.

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APPENDIX

Breed and Age Data for Littermate Pigs

Number assigned	Sex	Breed	Date born	Date slaught'd	Age (days)	Weight (kg)
DD50	gilt	Land Lac Y	Feb 27	July 29	153	100
DD51	boar	Land Lac Y	Feb 27	July 29	153	96
DD52	boar	Land Y	Mar 1	July 29	151	97
DD53	boar	Land Y	Mar 3	July 29	149	104
DD54	barrow	H Y	Mar 6	July 29	146	95
DD60	barrow	H Y	Mar 6	July 29	146	92
DD61	boar	H Y	Mar 6	July 29	146	93
DD62	boar	H Y	Mar 6	July 29	146	93
DD63	barrow	Land Lac Y	Feb 27	Aug 5	160	88
DD64	gilt	Land Y	Mar 1	July 29	151	96
DD70	barrow	Land Y	Mar 1	July 29	151	95
DD71	boar	Land Lac Y	Mar 3	Aug 5	156	90
DD72	boar	Land Y	Mar 3	Aug 5	156	96
DD73	boar	Land Y	Mar 7	Aug 5	152	92
DD74	boar	Land Lac Y	Mar 11	Aug 5	148	90
DD80	boar	Land Lac Y	Mar 13	Aug 5	146	92

Number assigned	Sex	Breed	Date born	Date slaugh'd	Age (days)	Weight (kg)
DD81	boar	Land Lac Y	Mar 3	Aug 12	163	93
DD82	gilt	Land Lac Y	Mar 5	Aug 12	161	92
DD83	gilt	H Y	Mar 6	Aug 12	160	88
DD84	boar	Land Y	Mar 7	Aug 12	159	81
DD90	boar	Land Lac Y	Mar 5	Aug 19	168	94
DD91	boar	H Y	Mar 6	Aug 26	174	95
DD92	boar	Land Y	Mar 7	Sept 2	180	77
DD93	boar	Land Lac Y	Mar 11	Sept 2	176	96
DD55	barrow	Land Y	Mar 3	Aug 5	156	90
DD56	barrow	Land Y	Mar 3	July 29	149	91
DD57	barrow	H Y	Mar 6	Aug 5	153	93
DD58	barrow	Land Lac Y	Mar 3	Aug 5	156	95
DD59	barrow	Land Y	Mar 7	Aug 5	152	81
DD65	barrow	Land Y	Mar 3	Aug 5	156	90
DD66	barrow	Land Lac Y	Mar 13	Aug 5	146	90
DD67	barrow	Land Lac Y	Feb 27	Aug 5	160	93

Number assigned	Sex	Breed	Date born	Date slaugh't	Age (days)	Weight (kg)
DD68	barrow	Land Y	Mar 7	Aug 5	152	91
DD69	barrow	Land Y	Mar 7	Aug 5	152	90
DD75	barrow	Land Lac Y	Mar 13	Aug 12	153	90
DD76	barrow	Land Lac Y	Mar 11	Aug 12	155	81
DD77	gilt	Land Y	Mar 1	Aug 5	158	97
DD78	gilt	Land Y	Mar 3	Aug 5	156	94
DD79	gilt	Land Y	Mar 1	Aug 5	158	97
DD85	gilt	Land Lac Y	Mar 5	Aug 5	154	90
DD86	gilt	Land Lac Y	Feb 27	Aug 12	167	90
DD87	gilt	Land Lac Y	Feb 27	Aug 12	167	89
DD88	gilt	Land Lac Y	Feb 27	Aug 12	167	94
DD89	gilt	Land Lac Y	Mar 5	Aug 12	161	92
DD94	gilt	Land Y	Mar 1	Aug 12	165	93
DD95	gilt	Land Lac Y	Feb 27	Aug 12	167	92
DD96	gilt	H Y	Mar 6	Aug 5	153	96
DD97	gilt	Land Lac Y	Mar 3	Aug 5	156	91

Correlation coefficients for odour rating *vs* age and weight

A. Boars from Department of Animal Science

odour rating - live weight	r= 0.08
odour rating - age	r= 0.07

B. Ridgelings from local packing plants

odour rating - dressed weight	r= 0.15

None of these correlations are statistically significant.

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